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One year of vertical wind profiles measurements at a Mediterranean coastal site of South Italy

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Abstract

To exploit wind energy both onshore and offshore in coastal area the effect of the coastal discontinuity is important. The shape of the vertical wind profiles and the related c parameter of the Weibull distribution are impacted by the atmospheric internal boundary layers developing from the coast along the wind direction. Here, we present first results: one year of vertical wind speed and direction profiles, monitoring programme at a South Mediterranean coastal site with a wind Lidar ZephIr (Ltd). Daily variation of wind speed and direction vertical profiles, vertical Weibull wind distribution c parameter and wind rose are here showed.

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Keywords: Wind; ZephIr; Coastal site; breeze; Weibull analysis;

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1. Introduction

The actual trend in developing specific new and advanced turbines for different operating conditions requires a deep analysis and understanding of the conditions in which a wind power plant will operate over its lifetime. The aim is to develop more cost-effective turbine designs in order to gain more wind energy with a longer lifetime and in specific operating environments.

This is the main reason why developing projects for wind farms need high quality databases under a wide range of atmospheric conditions or high resolution models that could resolve the effect of the coastal discontinuity in the surface properties.

New parametrizations are important and high quality databases are also needed for their formulation. Ground based remote sensing devices such as lidars in [1, 2] have been shown to be functional for studying the evolution of the vertical wind structure coastal atmospheric boundary layer both on- and offshore. Furthermore, concerning wind energy in [3, 4] detailed statistical analysis of Weibull distribution and parameter detection was conducted comparing/integrating wind measurement and forecasts.

Here, we present results from a unique dataset in the Mediterranean region, a year of vertical profiles of wind speed U and direction DIR , recorded at a site located in the Italian Calabria Region, Central Mediterranean area. We show the characterization of wind profiles for one year according to the time of the day to transition periods night/day and day/night classified relating the local scale, i.e. the breeze circulations, to the large scale conditions.

2. Experimental site and dataset

2.1. Experimental site

The experimental site is located in Calabria Region, at about 600m from the coastline at the west end of the only sea-to-sea valley around 30 km wide (the narrowest part of the region along west-east direction).

Calabrian region is a mountainous peninsula located at the southern tip of the Italian peninsula. It is about 50 km wide and elongated 300 km in the north south direction in the Central Mediterranean (Figure 1). The experimental area is flat and at the end of a west-east valley (the Marcellinara gap) that crosses the peninsula acting as a connecting channel between the Tyrrhenian and Ionian seas and surrounded by mountains.

This location is a natural laboratory to study land-sea interaction in complex terrain. The coastal flow is characterised by the interaction between synoptic winds and sea-breeze circulation. The synoptic wind comes usually from the west [5, 6].

Furthermore, sea breeze and land breeze act in phase with upslope and down-slope winds to determine stronger and more persistent breeze system.



Fig. 1. Experimental site.

Studies were conducted in the area using different approaches both by mesoscale models and short experimental campaign [8, 9] to characterize the local circulations and their interaction with large synoptic scale flow over the area.

2.2. Available Datasets

For the Lamezia Terme experimental site a data set is available as detailed in Table1.

Table 1. available dataset.

Instrument	Period	Data type	Time average	Profiles
Metmast Vaisala WTX250 (cfg1)	13/06/2013 – 20/11/2014*	WS, WD, T, RH, Prec., P,	10 min	Anemometer at an height a.g.l. of 8,5 m
Metmast Vaisala WTX250 (cfg2)	20/11/2014- actual	WS, WD, T, RH, Prec., P	10 min	Anemometer at an height a.g.l. of 10 m
Wind Lidar ZephIR 300 (firmware 1.x)	13/07/2013- - actual	WS, WD	10 min	Form 10 m – 300 m (avrg. 10 m)
*Real-time data are show on http://www.i-amica.it/iamica/?page_id=1122				

The wind monitoring activity at the surface is performed by a meteorological station Metmast Vaisala WTX250 10 m and a ZephIR 300 wind lidar provide vertical profiles of U and DIR , a sonic anemometer will be installed in the next month. where both instruments operate since July 2013. In particular ZephIR 300 wind lidars (profilers) from Natural Power is a continuous-wave (CW) lidar system that provides remote wind measurements across ten user-defined heights according to Table 1.

The wind “profiler” measures 10-min averaged quantities of the vertical wind speed profile, the vertical direction profile, and the vertical turbulence profiles, by combining a series of radial measured wind speed components from several, and at least three, different beam directions, into a three-dimensional wind vector. CW-based wind LIDARS measure the vertical wind profile at ten different heights selectable in the range from 10 to 300 meters height.

The comparison at 10 m height is possible with the metmast Vaisala WTX250 providing: Atmospheric Pressure, Precipitation, Relative Humidity, Temperature, Wind Speed and Direction averaged at 10 minutes with second configuration (cfg.2). At 10 m wind-lidar have a good according with met-mast measure at 10 m.

3. Data Analysis

3.1. Methodology and analysis

Here we present the characterization of wind profiles during one year period according to the time of the day to transition periods night/day and day/night classified relating the local circulations to the large scale conditions.

This type of analysis allow to study and characterize better the seasonal behavior, breeze regimes and transition between breeze developing during the day. Seasonal and daily wind-lidar measurements were analysed and show in Fig. 2. A detailed daily analysis was done on raw data (available every 10 sec.).

Analyses show during summer sea breeze regimes, stable-unstable daily cycle develops with wind profiles varying accordingly ([5]). Low level jets form during transition period. In order to characterized the wind profiles during one year period according to the time of the day to transition periods night/day and day/night classified relating the local scale to the large scale conditions.

A Weibull seasonal analysis [6, 3], was conducted to better characterise from an energy point of view breeze regime and influences form surroundings landscape influence the profiles for offshore flow despite to onshore breeze.

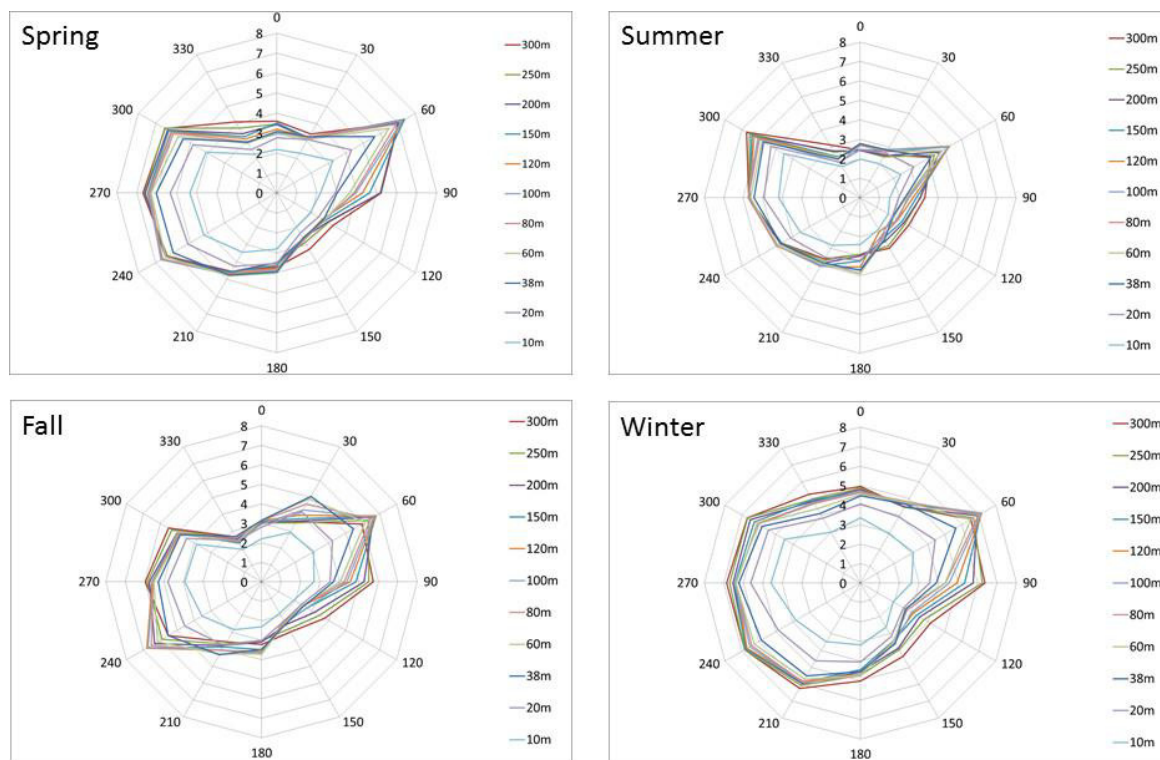


Fig. 2. Wind rose, wind speed and distribution for all levels from 10 to 300m.

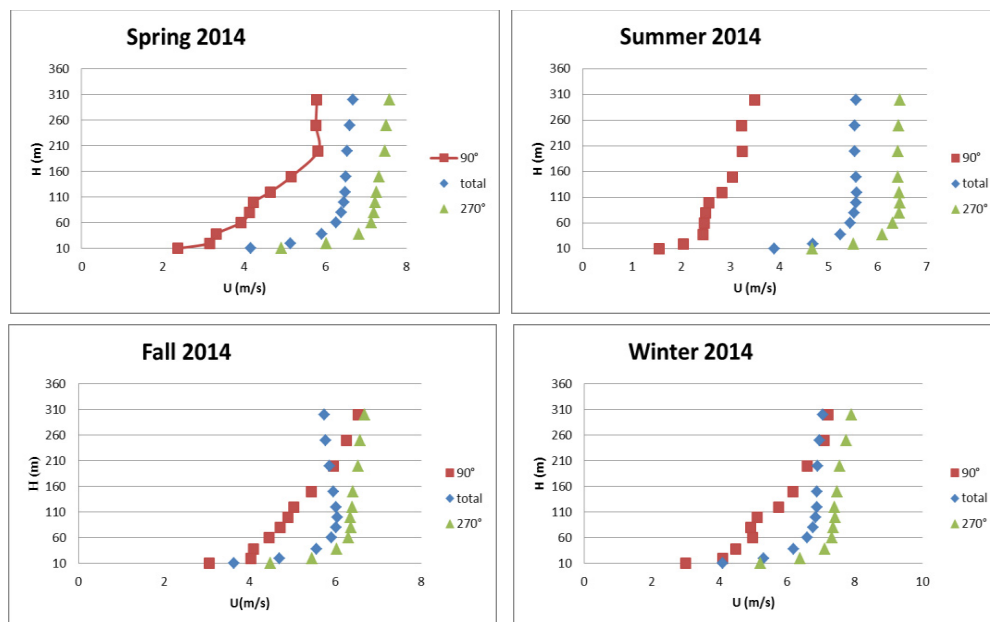


Fig. 3. Seasonal profiles of the C Weibull scale parameter estimated for all directions and onshore and offshore directions.

Bimodal distribution during spring and fall are more evident due to the high frequency of breeze presence, local circulation, respect to synoptic (general) circulation.

During fall an evident separation between levels 120 m and 150 m is registered. In all season the higher wind speed values are detected from offshore direction due to a higher presence of synoptic flow and storms coming from west direction, highest wind speed values occur in winter. The orographic effect, due to obstacles and coastline complexity show its decreasing influence on wind speed from onshore direction.

The Figure 3 below shows C Weibull shape parameter profiles. Both offshore and onshore C parameter profile are distinguished to better evidence orography influences during seasons.

Fig. 3 (top) the effect of the c Weibull shape parameter allow to understand and characterize influence of breeze in energy production

The suitable values for this parameter of Weibull distribution are important for selecting locations of installing wind turbine generators.

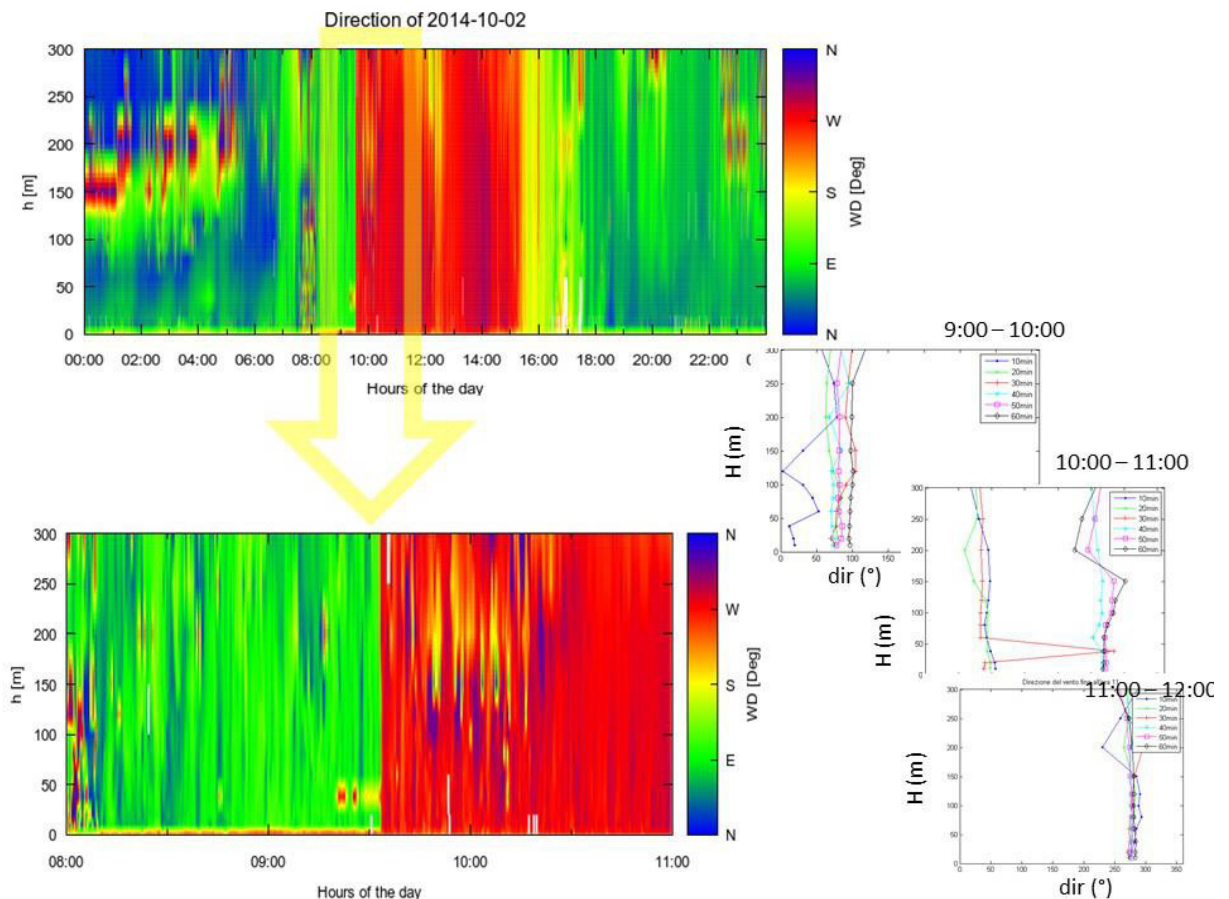


Fig 4 Breeze condition case: T1 zooming U and DIR profile variation during hour interval.

Figures 4 shows an example of wind profiles for a day characterized by breeze circulation: day, night, and transition T1 and T2 periods. Where T1 is the transition period night/day and T2 is the transition period Day/night.

It results in different profiles also due to different wind speed during day. An analysis of transition period (T1 night/day) are depicted in order to capture a better detailed profile.

Breeze regimes during transition period shows as breeze locally develops in less than one hour, in particular during time interval 9-10 a.m., while wind speed during direction inversion show uniformity for all levels, wind direction show incursion since 100 m height.

The Figure 5 below depict the case of strong synoptic flow in which transition periods are not present and wind direction is uniform for all the day. When the synoptic circulation is strong enough (Fig. 5.) local effects (breeze) the breeze circulation doesn't develop.

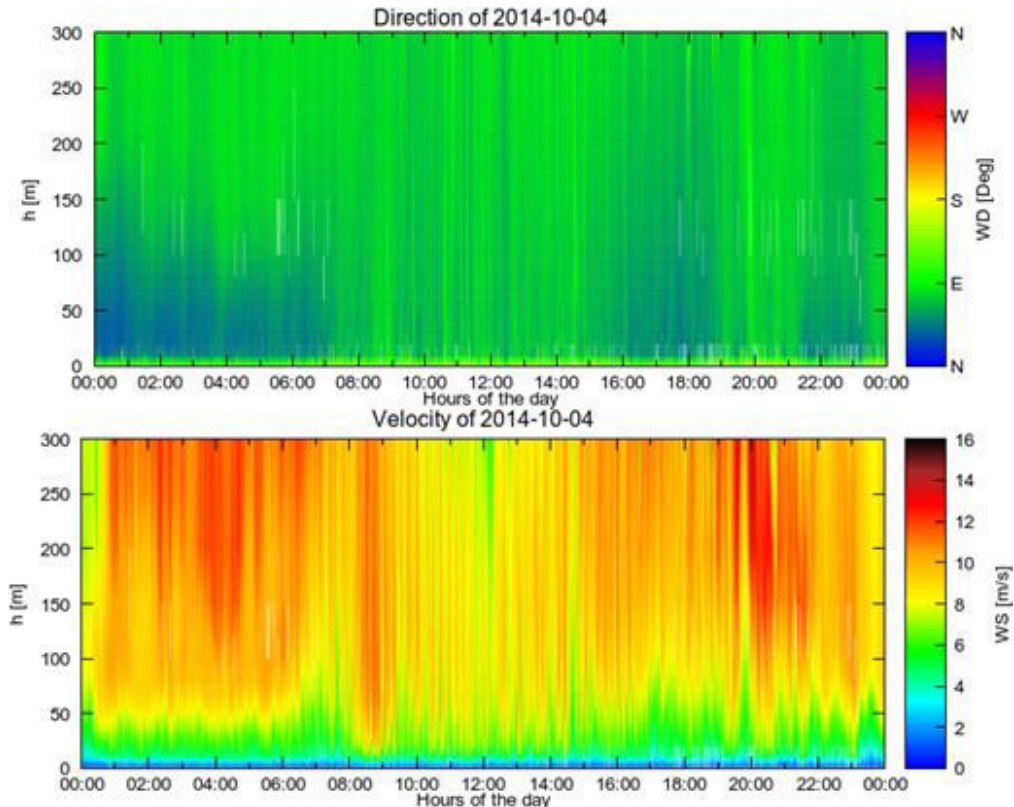


Fig. 5. Synoptic condition case: daily variation of wind direction profiles during 2014-10-04 and wind speed profiles during 2014-10-04.

4. Conclusion and future work

Among different renewable energy resources, wind power energy is one of the most important and promising energy resources in the world today. At a specific wind farm the available electricity generated depends on mean wind speed, standard deviation of wind speed, and the location of installation. In this study a seasonal and daily wind-lidar measurements were analysed. At 10 m wind-lidar have a good agreement with met-mast measure at 10 m. Analysis show during summer sea breeze regimes, stable-unstable daily cycle develops with wind profiles varying accordingly. Low-level jets are presents form during transition period. This study will performed considering the role of complex orography in this coastal site

Acknowledgements

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